AIR FORCE

QUALIFICATION TRAINING PACKAGE (AFQTP)

for

PAVEMENTS AND CONSTRUCTION EQUIPMENT OPERATOR

(3E2X1)

MODULE 20

RIGGING AND LIFTING

TABLE OF CONTENTS

MODULE 20

RIGGING AND LIFTING

Career Field Education and Training Plan (CFETP) references from 1 Apr 97 version.

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INTRODUCTION

Before starting this AFQTP, refer to and read the "Trainee/Trainer Guide" located on the AFCESA Web site **http://www.afcesa.af.mil/**

AFQTPs are mandatory and must be completed to fulfill task knowledge requirements on core and diamond tasks for upgrade training. ***It is important for the trainer and trainee to understand*** that an AFQTP ***does not*** replace hands-on training, nor will completion of an AFQTP meet the requirement for core task certification. AFQTPs will be used in conjunction with applicable technical references and hands-on training.

AFQTPs and Certification and Testing (CerTest) must be used as minimum upgrade requirements for Diamond tasks.

MANDATORY minimum upgrade requirements:

Core task:
AFQTP completion
Hands-on certification

Diamond task:
AFQTP completion
CerTest completion (80% minimum to pass)

Note: *Trainees will receive hands-on certification training for Diamond Tasks when equipment becomes available either at home station or at a TDY location*.

Put this package to use. Subject matter experts under the direction and guidance of HQ AFCESA/CEOF revised this AFQTP. If you have any recommendations for improving this document, please contact the Career Field Manager at the address below.

Notice. This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

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RIG LOADS TO BE LIFTED USING:

MODULE 20 **AFQTP UNIT 2**

CHAINS (20.2.1.)

WIRE ROPE (20.2.2.)

NYLON SLINGS (20.2.4.)

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RIG LOADS TO BE LIFTED USING:
CHAINS / WIRE ROPE / NYLON SLINGS
Task Training Guide

STS Reference Number/Title:	20.2.1. Chains 20.2.2. Wire Rope 20.2.4. Nylon Slings
Training References:	• TM5-725
Prerequisites	• Possess as a minimum a 3E2X1 AFSC
Equipment/Tools Required:	• Personal Protective Equipment • Chains • Wire Rope • Nylon Slings
Learning Objective:	• The trainee will be able to properly utilize chains, wire rope, and nylon slings as rigging and lifting devices
Samples of Behavior:	• The trainee will properly utilize chains, wire rope, and nylon slings as a rigging and lifting device
Notes:	
• Personnel are required to wear all personal protective equipment pertaining to each task (i.e. work gloves, hearing protection, and safety goggles)	
• Any safety violation is an automatic failure	

RIG LOADS TO BE LIFTED USING: CHAINS / WIRE ROPE / NYLON SLINGS

Background: Rigging is basically handling a load lifted by a crane or other piece of equipment. Each job that you rig will vary because of the size, shape, weight, and location of lift points. It is the rigger's responsibility to utilize the proper lifting materials and techniques to safely accomplish the job. Failure to do so creates a hazardous situation that may result in damage to the load, equipment, and possibly someone getting seriously hurt or killed.

Rigging typically involves the use of slings. The term sling includes a wide variety of designs. Slings may be made of chains, wire rope, or nylon.

- **Chain Slings:** Chain slings are frequently used for hoisting heavy steel items, such as rails, pipes, and beams. They are also handy for slinging hot loads and handling loads with sharp edges that might cut wire rope.

- **Wire Rope Slings:** Wire rope slings offer advantages of both strength and flexibility. These qualities make wire rope adequate to meet the requirements of most crane hoisting jobs; therefore, you will use wire rope slings more frequently than nylon or chain slings.

- **Nylon Slings:** Nylon slings are flexible and protect finished material more than wire rope slings but nylon slings are not as strong as wire rope or chain slings. Also, nylon is more likely to be damaged by sharp edges on material being hoisted than wire rope or chain slings.

No matter what material the sling is made of, it is important that the rigger understand that each has advantages and limitations. It is the rigger's responsibility to learn the characteristics of each so that the proper material is used when lifting loads. It is also important they are inspected prior to use and certified for particular lift capacities.

TYPES OF SLINGS:

Three types of slings are commonly used in the Air Force for lifting loads. They are the endless, single-leg, and combination (bridle) slings.

Endless Slings

The endless sling is made by splicing the ends of a piece of wire rope together or by inserting a cold-shut link in a chain. Cold-shut links should be welded after insertion in the chain. These endless slings are simple to handle and may be used in several different ways to lift loads. The different types of endless slings can be seen in Figure 1.

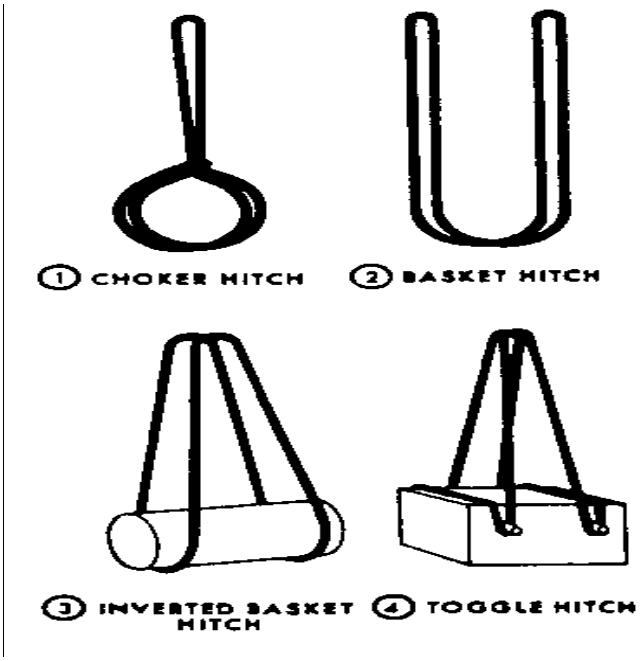


Figure 1, Endless Slings

- Choker or Anchor Hitch: A common method of using an endless sling is to cast the sling under the load to be lifted and insert one loop through the other and over the hoisting hook. When the hoisting hook is raised, one side of the choker hitch is forced down against the load by the strain on the other side, forming a tight grip on the load.

- Basket Hitch: With this hitch, the endless sling is passed around the object to be lifted and both remaining loops are slipped over the hook.

- Inverted Basket Hitch: This hitch is very similar to the basket hitch. The difference is the two parts of the sling going under the load are spread wider apart.

- Toggle Hitch: The toggle hitch is used only for special applications. It is actually a modification of the inverted basket hitch except the line passes around toggles fastened to the load rather than going around the load itself.

Single Slings

A single sling can be made of chain, wire or nylon rope. Each end of a single sling is made into an eye or has an attached hook (Figure 2). In some instances the ends of a wire rope are spliced into the eyes that are around thimbles, and one eye is fastened to a hook with a shackle. With this type of sling, you can remove the shackle and hook when desired. A single sling can be used several different ways for hoisting (Figure 2). It is advisable to have four single slings of wire rope available at all times. These can be used singularly or in combination, as necessary.

Choker or Anchor Hitch: A choker or anchor hitch is a single sling used for hoisting by passing one eye through the other eye and over the hoisting hook. A choker hitch will tighten down against the load when a strain is placed on the sling.

Basket Hitch: A basket hitch is a single sling that is passed under the load with both ends hooked over the hoisting hook.

Stone-Dog Hitch: A stone-dog hitch is single slings with two hooks used for lifting stones.

Double Anchor Hitch: This hitch is used for hoisting drums or other cylindrical objects where it is necessary for the sling to tighten itself under strain and lift by friction against the sides of the cylinder.

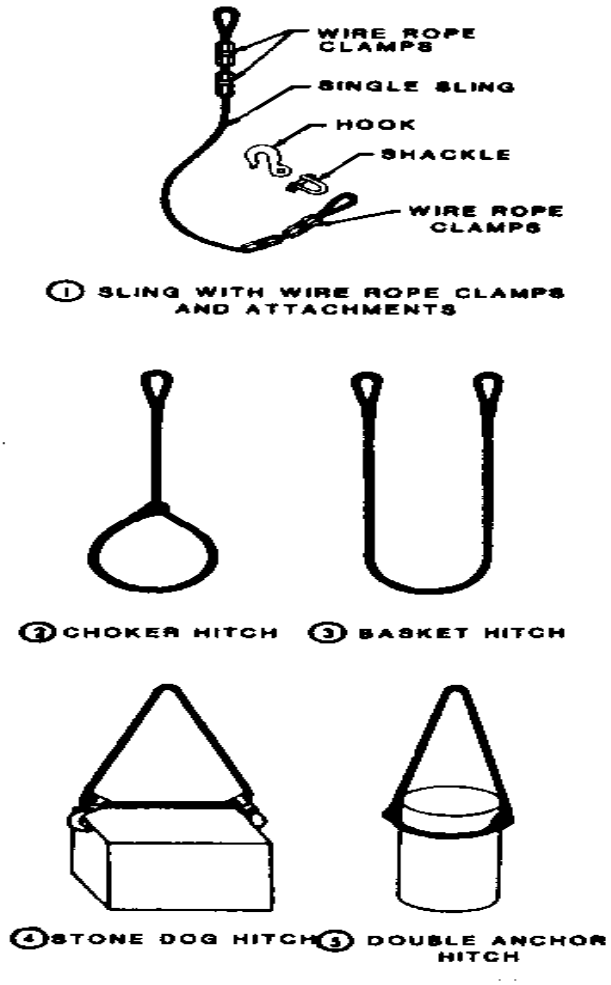


Figure 2, Single Slings

Combination Slings

Single slings can be combined into bridle slings, basket slings, and choker slings to lift virtually any type of load. Either two or four single slings can be used in a given combination. Where greater length is required, two of the single slings can be combined into a longer single sling. One problem in lifting heavy loads is fastening the bottom of the sling legs to the load in such a way the load will not be damaged. Lifting eyes are fastened to many pieces of equipment at the time it is manufactured. On large crates or boxes, the sling legs may pass under the object to form a gasket sling. A hook can be fastened to the eye on one end of each sling leg to permit easier fastening on some loads. When the load being lifted is heavy enough or awkward, a four-leg sling may be required. If a still greater length of sling is required, two additional slings can be used in conjunction with the four-leg sling to form a double basket.

Bridle Hitch: The bridle hitch provides excellent load stability when the load is distributed equally among each sling leg. The hook is placed directly over the center of gravity of the load, so the load is raised level. The use of bridle slings requires the angle to be carefully determined to ensure the individual legs are not overloaded. With a four-legged bridle sling lifting a rigid load, it is possible for two legs to support practically the full load while the other two only balance it.

Use a protective pad when a nylon or wire rope sling is exposed to sharp edges at the corners of a load. Pieces of wood or rubber tires are fine for padding.

Spreaders

Occasionally, it is necessary to hoist loads that are not protected sufficiently to prevent crushing by the slings. In such cases, spreaders may be used in conjunction with slings (Figure 3). Spreaders are short bars or pipes with eyes on each end. The sling leg passes through the eye down to its connection with the load. By setting spreaders in the sling legs above the top of the load, the angle of the sling leg is changed so that crushing the load is prevented. Changing the angle of the sling leg may increase the stress in that portion of the sling leg above the spreaders. The determining factor in computing the safe lifting capacity of the sling is the stress (or tension) in the sling leg above the spreader.

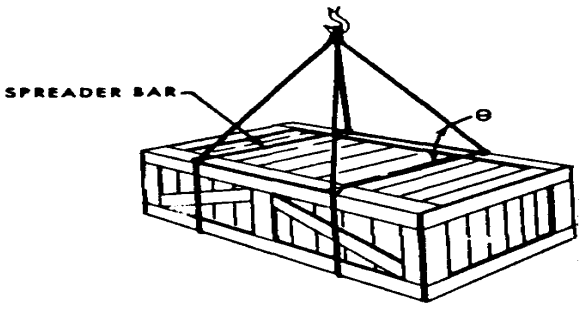


Figure 3, Use of Spreader Bars in Slings

STRESSES

In order to safely lift loads it is necessary to determine the tension that will be applied to the slings you use. Table-1 and Table-2 list the Safe Working Capacity (SWCs) of chains and wire-rope slings under various conditions. As a rigger, it is important for you to be able to determine if the tension or stress that will be applied by the load is within the SWC of the sling. If not, you need to get the appropriate type and size slings to do the job safely.

Safe Working Capacity (SWC) for Chain Slings (now wrought-iron chains)

Link Stock Diameter (Inches)	Single Sling	Double Sling			Quadruple Sling		
	Vertical Lift (Pounds)	60° Angle (Pounds)	45° Angle (Pounds)	30° Angle (Pounds)	60° Angle (Pounds)	45° Angle (Pounds)	30° Angle (Pounds)
3/8"	2,510	4,350	3,555	2,510	8,700	7,110	5,020
7/16"	3,220	5,575	4,560	3,220	11,150	9,120	6,440
1/2"	4,180	7,250	5,915	4,180	14,500	11,830	8,360
9/16"	5,420	9,375	7,670	5,420	18,750	15,340	10,840
5/8"	6,460	11,175	9,150	6,460	22,350	18,300	12,920
3/4"	9,160	15,850	12,950	9,160	31,700	25,900	18,320
7/8"	13,020	22,550	18,410	13,020	45,100	36,8620	26,000
1"	17,300	29,900	24,450	17,300	59,800	48,900	34,600
1-1/8"	21,550	37,350	30,550	21,550	74,700	61,100	43,100
1-1/4"	26,600	46,050	37,600	26,600	92,100	75,200	53,200
1-3/8"	32,200	55,750	45,600	32,200	111,500	91,200	64,400
1-1/2"	38,300	66,400	54,250	38,300	132,800	108,500	76,600
1-5/8"	44,600	77,200	63,050	44,600	154,400	126,100	89,200
1-3/4"	51,300	88,750	72,500	51,300	177,500	145,000	102,600
1-7/8"	58,700	101,500	83,000	58,700	203,000	166,000	117,400
2"	66,200	114,500	93,500	66,200	229,000	187,000	132,400

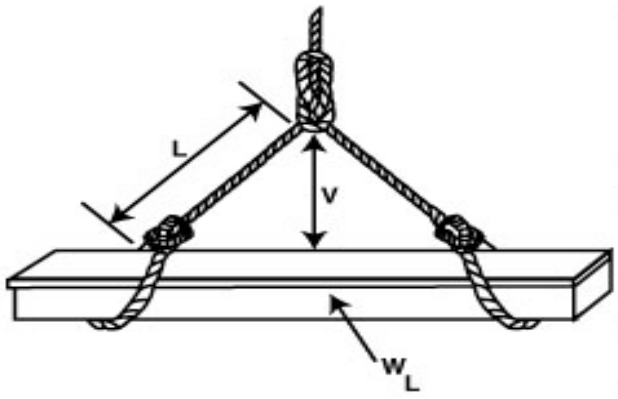
Table-1

The angle of the legs of a sling must be considered as well as the strength of the material the sling is constructed of. The lifting capacity of a sling is reduced as the angle of its legs to the horizontal is reduced. Reducing the leg angle of a sling increases the tension on the sling legs.

Safe Working Capacity (SWC) for Wire-Rope Slings (new, IPS wire rope)

Diameter (Inches)	Single Sling	Double Sling			Quadruple Sling		
	Vertical Lift (Pounds)	60° Angle (Pounds)	45° Angle (Pounds)	30° Angle (Pounds)	60° Angle (Pounds)	45° Angle (Pounds)	30° Angle (Pounds)
1 / 4”	1,096	1,899	1,552	1,096	3,798	3,105	2,192
5/16”	1,690	2,925	2,390	1,690	5,850	4,780	3,380
3/8”	2,460	4,260	3,485	2,460	8,520	6,970	4,920
7/16"	3,560	6,170	5,040	3,560	12,340	10,080	7,120
1/2"	4,320	7,475	6,105	4,320	14,950	12,210	8,640
9/16"	5,460	9,450	7,725	5,460	18,900	15,450	10,920
5/8"	6,650	11,500	9,400	6,650	23,000	18,800	13,300
3/4"	9,480	16,400	13,400	9,480	32,800	26,800	18,960
7/8"	12,900	22,350	18,250	12,900	44,700	36,500	25,800
1"	16,800	29,100	23,750	16,800	58,200	47,500	33,600
1-1/8"	21,200	36,700	30,000	21,200	73,400	60,000	42,400
1-1/4"	26,000	45,000	36,800	26,000	90,000	73,600	52,000
1-3/8"	32,000	55,400	45,250	32,000	110,800	90,500	64,000
1-1/2"	37,000	64,000	52,340	37,000	128,000	104,700	74,000
1-5/8"	41,800	72,400	59,200	41,800	144,800	118,400	83,600
1-3/4"	49,800	86,250	70,500	49,800	172,500	141,000	99,600
2"	62,300	107,600	88,050	62,300	215,200	176,100	124,600
2-1/4"	82,900	143,500	117,400	82,900	287,000	234,800	165,800
2-1/2"	101,800	176,250	144,000	101,800	352,500	288,000	203,600
2-3/4"	122,500	212,000	173,500	122,500	424,000	347,000	245,000

Table-2



Tension in a sling leg

$$T = \frac{W_L}{N} \frac{L}{V}$$

T = Tension in a single leg

W_L = Weight of load

N = Number of sling legs

L = Length of sling leg

V = Vertical distance of sling

Figure 4. Computing tension in a sling

In determining the proper size of sling, you must determine the tension on each leg for each load (Figure 4). You can compute this tension using the following formula:

*T=(W÷N) * (L÷V)*

T = Tension in a single sling leg (which may be more than the weight of the load lifted)

W = Weight of load to be lifted

N = Number of slings

L = Length of sling

V = Vertical distance, measured from the hook to the top of the load

NOTE:

- L and V must be expressed in the same unit of measure.
- The resulting tension will be the same unit of measure as the weight of the load. Thus, if the weight of the load is in pounds, the tension will be given in pounds

Example: Determine the tension of a single leg of a two-legged sling being used to lift a load weighing 1,800 pounds. The length of a sling is 8 feet and the vertical distance is 6 feet.
Solution:

$T=(W\div N) * (L\div V)$

$T=(1,800\div 2) * (8\div 6) = 1,200$ pounds or 6 tons

By knowing the amount of tension in a single leg, you can determine appropriate size of wire rope or chain. The SWC of a sling leg (keeping within safety factors for slings) must be equal to or greater than the tension on a sling leg. If possible, keep the tension on each sling leg below that in the hoisting line to which the sling is attached. A particular angle formed by the sling legs with the horizontal where the tension within each sling leg equals the weight of the load, is called the critical angle (Figure 3-9). Approximate this angle using the following formula:

Critical angle = 60÷N

N = Number of sling legs

When using slings, stay above the critical angle and remember the greater the angle from vertical, the greater the stress on sling legs.

The rated capacity of any sling depends on the size, configuration, and angles formed by the legs of the slings and the horizontal. A sling with two legs lifting a 1,000-pound object will have 500 pounds of the load on each leg when the sling angle is 90° (figure 5). The load stress on each leg increases as the angle decreases. For example, if the sling angle is 30° when lifting the same 1,000-pound object, the load is 1,000 pounds on each leg. Try to keep all sling angles greater than 45° since sling angles approaching 30° are considered extremely hazardous and must be avoided.

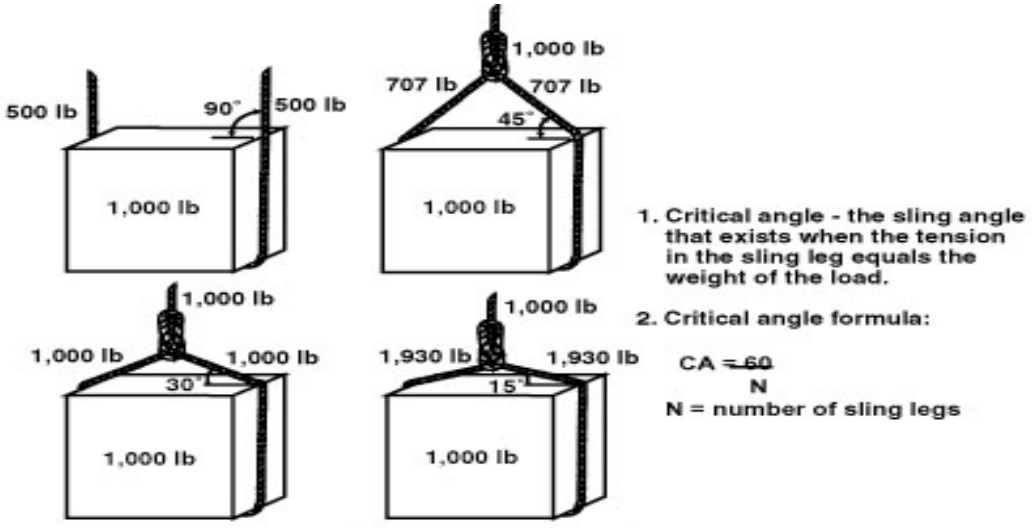


Figure 5. Sling angles

INSPECTING AND CUSHIONING SLINGS

Inspect slings periodically and condemn them when they are no longer safe. Make the usual deterioration check for chains and hooks, wire ropes, and nylon when you use them in slings. Besides the usual precautions, declare wire ropes used in slings unsafe if 4% or more of the wires are broken. Pad all objects to be lifted with wood blocks, heavy fabric, old rubber tires, or other cushioning material to protect the legs of slings from being damaged.

SELECT SLINGS

The rigger is responsible for selecting the slings to use for the job. The following are some factors to consider in selecting the proper sling:

Determine the weight of the load to be lifted.

Decide on the appropriate hitch to use that accommodates the size and shape of the load.

Check the lifting device to ensure it has sufficient capacity, maneuverability, and is working properly.

Ensure there is plenty of room to lift the object (consider sling length).

Select sling length. Use longest sling possible in order to reduce angle of spread.

Determine safe working load capacity of sling.

Use the correct leg style (single or multi-part).

NOTE:
DO NOT forget it is wrong to assume that a three- or four-leg hitch can safely lift a load equal to the safe load on one leg multiplied by the number of legs.

Review Questions
for

Rig Loads to be Lifted Using:
Chains / Wire Rope / Nylon Slings

Question	Answer
1. How many different types of slings are used in the Air Force?	a. 2 b. 3 c. 4 d. 5
2. Endless slings have an eye on each end or an eye on one end and a hook on the other end.	a. True b. False
3. Spreader bars are used to prevent crushing the load.	a. True b. False
4. Sling angles approaching _____ degrees are considered extremely dangerous and must be avoided.	a. 25 b. 30 c. 45 d. 90

RIG LOADS TO BE LIFTED USING:
CHAINS / WIRE ROPE / NYLON SLINGS

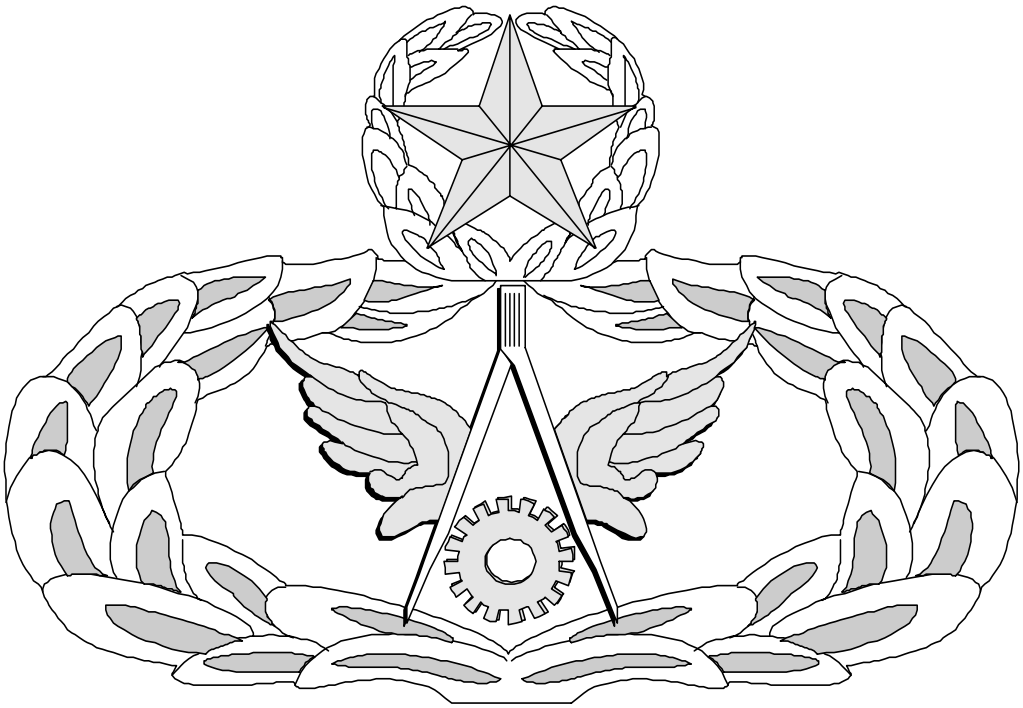
Performance Checklist		
Step	**Yes**	**No**
1. Utilized correct type of sling for the job?		
2. Formed an endless sling?		
3. Formed a choker hitch?		
4. Formed a single-leg sling or strap?		
5. Formed multi-legged bridle slings?		
6. Utilized spreader bar(s)?		

FEEDBACK: Trainer should provide positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.

Air Force Civil Engineer

QUALIFICATION TRAINING PACKAGE (QTP)

REVIEW ANSWER KEY



For

PAVEMENTS & CONSTRUCTION EQUIPMENT OPERATOR

(3E2X1)

MODULE 20

RIGGING AND LIFTING

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Rig Loads to be Lifted Using:

Chains / Wire Rope / Nylon Slings

(3E2X1-20.2.1. & 20.2.2. & 20.2.4.)

Question	Answer
1. How many different types of slings are used in the Air Force?	b. 3
2. Endless slings have an eye on each end or an eye on one end and a hook on the other end.	b. False
3. Spreader bars are used to prevent crushing the load.	a. True
4. Sling angles approaching _____ degrees are considered extremely dangerous and must be avoided.	b. 30